A critique of schema theory in reading and a dual coding alternative

FOR MORE than a decade, reading research has been influenced by schema theory, which hypothesizes the existence of abstract structures for the representation of knowledge in memory (schemata). This article evaluates schema theory on a variety of grounds and presents dual coding theory as a theoretical alternative. It is argued that schema theory is encumbered by lack of a consistent definition, its roots in idealist epistemology, and mixed empirical support. Critical analysis of key schema research, including sentence integration studies, bizarre text studies, and perspective studies, suggests that much of the empirical basis of schema theory may derive from procedural singularities and methodological demonstrations. Moreover, we argue that the results of many empirical studies used to demonstrate the existence of schemata are more parsimoniously and consistently explained by dual coding theory. Dual coding theory suggests that cognition consists of two separate but interconnected mental subsystems, a verbal system and a nonverbal system. We review various other theories of cognition in reading that have adopted provisions for mental modeling that render them tantamount to dual coding theory. Finally, we look at results of recent studies of imagery and affect in reading and suggest that dual coding offers a better explanation of the effects than does schema theory.

Critique de la théorie des schémas en lecture et proposition d’un modèle alternatif: Le modèle du double codage

DEPUIS PLUS DE dix ans, la recherche en lecture a été influencée par la théorie des schémas proposée comme un modèle de représentation des connaissances dans la mémoire. Toutefois nous suggérons que la théorie des schémas souffre de problèmes de définition, qu’elle prend racine dans une épistémologie idéaliste et que les supports empiriques sur lesquels elle s’appuie sont mitigés. Une évaluation critique de recherches classiques sur les schémas
incluant les recherches sur l'intégration des phrases, sur les textes atypiques et sur l'effet de perspectives suggère qu'une partie importante du support empirique de la théorie des schémas s'effrite en raison de problèmes de procédures et de démonstrations artificielles. De plus nous tenterons de montrer que les résultats de plusieurs recherches s'expliquent mieux avec la théorie du double codage. La théorie du double codage suggère que la cognition s'appuie sur deux systèmes séparés mais interreliés: un système verbal et un système non verbal. Nous examinerons d'autres théories de la cognition en lecture qui se sont penchées sur le problème de la représentation des connaissances et qui sont équivalentes à la théorie du double codage. Finalement nous examinerons les résultats de recherches récentes en lecture sur l'imagier mental et sur l'affectivité et nous montrons que la théorie du double codage propose de meilleures explications de leurs effets que la théorie des schémas.

Una crítica a la teoría de esquemas en la lectura y una alternativa de codificación dual

POR MÁS DE UNA década la investigación enfocada en la lectura ha sido influida por la teoría de esquemas, la que conceptualiza las estructuras abstractas por la representación del conocimiento en la memoria. Sin embargo, nosotros discutimos que la teoría de esquemas es defectuosa por falta de una definición consistente, por estar sus raíces en una epistemología idealista, y tener un soporte empírico mixto. La evaluación crítica de los estudios de esquemas más importantes, incluyendo los de integración de oraciones, los estudios de texto bizarro, y los de perspectiva, sugiere que mucha de la base empírica en la que se apoya la teoría de esquemas se deriva de peculiaridades de procedimiento y demostraciones sesgadas. Por otra parte, discutimos que los resultados de muchos estudios empíricos usados para demostrar la existencia de esquemas son explicados de forma más parsimoniosa y consistente por la teoría de codificación dual. La teoría de codificación dual sugiere que la cognición consiste en dos subsistemas mentales separados pero interconectados, un sistema verbal y un sistema no verbal. Examinamos varias otras teorías de cognición en lectura que han adoptado requisitos para el modelado mental que las convierten en equivalentes a la teoría de codificación dual. Finalmente revisamos los resultados de estudios recientes en imaginación y su efecto en la lectura y sugerimos que la codificación dual es una explicación mejor de los efectos que la de la teoría de esquemas.

Eine Kritik der Schematheorie des Lesens und eine Dualkodierung als Alternative

Studien neueren Datums in Betracht, die sich mit innerlichen Bildern und Affekt beim Lesen befaßten, und schlagen vor, daß die Dualkodierung eine bessere Erklärung der Wirkungen darstellt als es anhand der Schematheorie möglich ist.

Reading research has been influenced by schema theories for nearly two decades. Schemata are theorized to be abstract knowledge structures (Anderson & Pearson, 1984) or data structures for representing generic concepts stored in memory (Rumelhart, 1980b; Rumelhart & Ortony, 1977). Although several terms have been used to designate abstract knowledge and memory structures, such as frames (Minsky, 1975), scripts (Schank & Abelson, 1977), plans (Schank, 1982), and macrostructures (Kintsch & van Dijk, 1978), the terms schema and schemata have gained preference, and the term schema theory is often used inclusively, as it will be in this paper, to refer to all models of this type.

Schema theory has had broad heuristic value, leading to theory development and inspiring a wealth of research across a number of domains. In reading research, schema theory has had two major salutary effects, focusing attention on (a) the constructive nature of comprehension and (b) the crucial role of the reader’s prior knowledge in that construction. Schema theory, along with the theories of Goodman, Smith, and others, has constituted an effective counterweight to bottom-up or data-driven models of reading (e.g., Gough, 1972) that have downplayed or neglected constructive, conceptually driven processes. As Anderson and Pearson (1984) have pointed out, schema theory has challenged our thinking about issues such as how information in text is assimilated, how inferences are made, and how text is remembered.

On the other hand, the ascendancy of schema theory in reading has not been without its drawbacks. First, the pervasive use of the term schema has at times created an illusion of consensus and has left the impression that we have a more profound understanding of cognition in reading than we do. It appears that, for many reading researchers and educators, the term schema has for all practical purposes become synonymous with prior knowledge or background knowledge. This development has been less than fortunate because, although it is an accepted fact that readers possess knowledge and use this knowledge in constructing meaning, the question of how this knowledge is represented, organized, and used is a subject of considerable debate in cognitive psychology. Second, in characterizing all knowledge as being represented abstractly, schema theory has ignored the roles of imagery and emotional response in reading. In this paper, we offer a critique of schema theory as it is reflected in current reading research (e.g., Anderson, 1977, 1984; Anderson & Pearson, 1984; Rumelhart, 1980b; Rumelhart & Ortony, 1977; Schallert, 1982, 1991) in the hope of sparking renewed debate on the nature and role of readers’ knowledge, and we present an alternative model, dual coding theory, that incorporates imagery and affective response. Specifically, we will (a) review some general criticisms of schema theories, (b) evaluate some key studies of schema theory in reading, (c) provide a dual coding theoretical alternative that can account for present data and relevant new data, and (d) compare and contrast dual coding with other theories such as semantic network models (e.g., Collins & Loftus, 1975) and van Dijk and Kintsch’s (1983) discourse processing model.

General criticisms of schema theories

Definitional vagueness

The idea that knowledge might be represented schematically has surfaced from time to time in the history of philosophy and psychol-
ogy. Contemporary schema theory in reading is usually traced to Kant's *Critique of Pure Reason* (1781/1963) and to Bartlett's *Remembering* (1932), although it might as easily be traced to Plato's later thinking or to Piaget. More recently, the work of Minsky and others in artificial intelligence has been instrumental in reviving interest in schema theory. A persistent problem with such notions has been the definition of what constitutes a schema. Anderson, Spiro, and Anderson (1978, p. 439) observed that "until recently schema notions were hopelessly vague." Unfortunately, it is not clear that contemporary schema theory has overcome this difficulty. Brown (1979) made this point amusingly:

> The defining features of schema theories are somewhat difficult to specify. The use of the term schema is widespread, vague, and not always overladen with meaning. One of my favorite games is to remove the word schema from a paper written in schematose and look for changes in meaning. Take, for example, the sentence "preexisting knowledge schemata function to orient people to interpret a message in a certain way." Where is the loss of clarity in removing the word schemata? It is somewhat surprising to find that there rarely is a loss of meaning following such ablation tactics. (p. 231)

Many other researchers have noted that the term schema has no fixed definition and is so general and vaguely specified that each theorist has proposed a different formalization of its features, structure, and function (Brewer & Treyens, 1981; Taylor & Crocker, 1981). Accordingly, the most influential definitions have been metaphorical. Hence, schemata are defined as "frameworks" with “slots” to be filled, or “packets” of knowledge contained within larger “packets” of knowledge. A schema is defined as analogous to a play; that is, a general schema is to an instantiated schema as the script of a play is to a particular performance.

Many important theories have had metaphorical bases (e.g., the telephone switchboard for stimulus-response connections, the computer for human information processing, the solar system as a model of the atom), but problems can arise when different, conflicting metaphors are used to explain the same phenomenon (e.g., wave vs. particle theories of light). Schemata are also variously defined by comparison to stereotypes, prototypes, templates, scripts, plans, and grammars. Hence we have prototypical or template schemata for concepts such as birds, vehicles, weapons, or furniture; we have scripts or plans for events such as dining in restaurants, going to birthday parties, washing clothes, or burgling homes; and we have grammars for typical stories, such as mysteries or folktales. Some schema theorists appear to have adopted the proposition as the basic unit of knowledge that comprises all schemata (Anderson & Pearson, 1984), whereas others do not use that term and variously posit templates, prototypes, features, and atomic subschemata as basic elements (Rumelhart, 1980b; Rumelhart & Ortony, 1977). The multitude of terms and metaphors suggests confusion about the basic nature of schemata (cf. Iran-Nejad, 1989).

There is also confusion regarding the nature of the knowledge that constitutes a schema and regarding the degree of abstraction that must occur before a schema can be said to exist. Therefore, it is not clear in schema theory whether we have an overall schema for color that is made up of particular colors (e.g., red, yellow) or schemata for particular colors that are made up of particular examples of these colors (e.g., fire engine red, lemon yellow). This problem is sometimes solved by postulating embedded schemata, or schemata within schemata. However, this approach invites infinite regress and theoretical circularity, problems that trouble many cognitive theories. Such problems led Bartlett (1932) to conclude that defining a schema may be ultimately infeasible:

> I strongly dislike the term “schema.” It is at once too definite and too sketchy.... It would probably be best to speak of “active, developing patterns;” but the word “pattern,” too, being now very widely and variously employed, has its own difficulties. (pp. 200-201)
Reification

An epistemological issue that confronts schema theory is the notion of *reification*, attributing actual existence to something that is only a name or an abstraction. Schemata are, by most accounts, abstractions derived from experience that exist in a potential, nonspecific state, awaiting input. The epistemological question is how conceptual or schematic knowledge can exist in the abstract, isolated from any of the examples that gave rise to it.

To illustrate, let us briefly consider a classic example. Kant (1787, cited in Rumelhart & Ortony, 1977, p. 101) suggests that we have a schema for triangles in the abstract; no image of a triangle could ever be adequate to cover the concept of triangles in general. Presumably Kant refers to static images here, as imagining a flexible triangle whose angles and side lengths could change as long as they remained connected would account for all possible triangles. Kant further suggests that an image is a product of reproductive, sensory imagination, whereas a schema is a product of productive, *a priori* imagination, free from empirical sense data. However, Bossart (1986) shows how Kant in fact makes no principled distinction between reproductive and productive imagination, and employs the term *schema* as a bridge between the two, so that in the last analysis one cannot exist independently of the other. Klein (1984) comes to a similar conclusion regarding the epistemology of triangles; that is, any single triangle symbolizes all triangles in the universe, whether past, present, or future, needing only imaginative transformations to complete the set. Skemp (1987), in his analysis of the psychology of mathematics, identifies mathematical thought as among the most abstract forms of thought. However, he concludes that, even in mathematics, primary concepts (e.g., line, intersection, angle, triangle) are formed on the basis of concrete sensory experience and classified by language, whereas abstract, higher order concepts (e.g., polygon) are made possible through further linguistic definition. Hence, concrete experience is at the foundation of all mathematical thought, arguably the most abstract form of thought. Paivio (1971, p. 438) has likewise suggested that other abstract patterns such as syntactic sequences in fact lie on a foundation of imagery and concrete experience.

Although we cannot resolve the epistemological question of abstraction, it is important to note that there is no universal agreement among philosophers and theorists about whether completely abstract schemata can exist or whether such constructs are examples of reification. Such constructs are particularly troublesome for scientific theorizing because of the difficulty of formulating alternatives, operationalizing variables, and devising adequate empirical tests. Consequently, there is a paucity of research testing schema theory against other theories; the theory has mainly been tested within its own framework of assumptions (e.g., slot-filling vs. selective attention models, both of which assume an overriding schema).

Empirical evidence

Several critiques of schema theory have been published (Dresher & Hornstein, 1976; Iran-Nejad, 1987b; Paivio, 1986, pp. 224-229; Taylor & Crocker, 1981), as well as critiques of story grammars (Black & Wilensky, 1979; Brewer & Lichtenstein, 1981; Johnson-Laird, 1983, pp. 361-377; Thorndyke & Yekovich, 1980; but for responses see Mandler, 1984, pp. 109-113; Mandler & Johnson, 1980; Rumelhart, 1980a). Perhaps the most comprehensive and incisive critique of schema theories in general was made on empirical grounds by Alba and Hasher (1983). They defined schema theory by identifying central assumptions common to all schema theories, then systematically reviewed empirical studies that were consistent and inconsistent with each assumption, and reviewed alternative explanations for the findings.

Alba and Hasher (1983) identified four encoding processes and one retrieval process that were assumed by all schema theories. The encoding processes are (a) selection, a process that selects some information for representation; (b) abstraction, a process that stores the meaning of a message but not its surface (syntactical and lexical) structure; (c) interpretative
tion, a process through which relevant background knowledge is mobilized to aid comprehension; and (d) integration, a process by which a unitized memory representation is formed from the products of the previous operations. The retrieval process, reconstruction, involves using whatever details are still accessible, together with general knowledge, to refabricate the episode. The review then focuses on the adequacy of schema theory in accounting for three fundamental characteristics of memory: accuracy, incompleteness, and distortion.

The conclusions drawn by Alba and Hasher (1983) from their review of schema theory are straightforward: Schema theory fails to account for the rich and accurate detail of complex events and episodes frequently observed in memory research. The encoding processes of selection and abstraction reduce the amount of information stored in memory, but evidence from numerous studies suggests that the memory trace for complex events is richer and more detailed than these processes would allow. The process of integration does not appear to be obligatory; numerous studies show that uninterpreted and unintegrated information is also available for recall under various conditions. Distortions and the imposition of personal interpretations were found to be less common than is often stressed in the schema literature, and when interpretations are generated, people are frequently aware of the difference between internally generated and externally derived information.

In summary, Alba and Hasher (1983) suggest that the results of schema theory research can be explained by assuming that a detailed representation of a complex event is stored in memory, and that what people show of what they have stored will depend on a variety of circumstances, such as encoding and/or recall instructions, context effects, and the nature of the materials. In fact, they conclude that “much of the original support for schema theory encoding processes stemmed from procedural peculiarities of landmark experiments” (p. 219). As we shall see, this is a criticism that may apply particularly to schema studies in reading. Finally, and perhaps most importantly for the present discussion, Alba and Hasher conclude that many nonschematic concepts are available to explain memory for complex events.

In summary, schema theory is beset by general definitional, epistemological, and empirical problems. We will now turn to the specific evaluation of some key schema studies in reading, and then to an alternative interpretation of those and other studies.

**Critique of key schema studies**

Certain studies have been particularly influential in the popularization of schema theory in reading. Our focus here will be on empirical studies that have been widely cited, replicated, and used as evidence of the existence of schemata.

**Sentence integration studies**

Chief among the early studies cited as evidence for schemata are the sentence integration experiments of Bransford and his colleagues. Bransford and Franks (1971) investigated the schema-theoretic processes of abstraction and integration by examining subjects’ recall of related sentences. Subjects were presented with four propositions embedded in complex sentences (e.g., The ants in the kitchen ate the sweet jelly which was on the table), and with various subsets of those propositions (e.g., The ants ate the jelly). During the subsequent recognition test, previously presented sentences were presented, along with new sentences that were either consistent or inconsistent with the propositions presented at acquisition.

Results indicated that subjects correctly recognized previously presented sentences that contained more propositions better than those that contained fewer propositions. In addition, subjects incorrectly “recognized” many new-but-consistent sentences that were never actually presented, and rejected some new-but-inconsistent sentences. Bransford and Franks (1971) concluded that subjects acquired an abstracted and integrated representation of the
meaning of the sentences, but not an accumula-
tion of individual sentence or word meanings,
as the integrated representation encompassed
more information than any of the original sen-
tences contained. Inconsistent information was
consistently rejected, suggesting considerable
precision in the integrated representation.

As evidence for schema theory, this study
poses many problems. Alba and Hasher (1983)
reviewed the extensive replications of the
Bransford and Franks (1971) study as follows:

Integration is the set piece of schema theories.
Theoretically, meaning is abstracted from the
stimuli that have been selected, and related ab-
stractions are joined into a single representation.
The most impressive contemporary evidence in
support of this notion came from Bransford and
Franks (1971). As is now widely acknowledged,
there are many grounds on which to challenge
their conclusions. The most basic is the fact that
integration is not a necessary product of encod-
ing related events (Moeser, 1976, 1977). In fact,
the Bransford and Franks (1971) findings are
difficult to replicate unless their methods are
followed closely. Changes in presentation mo-
dality (Flagg & Reynolds, 1977; see also Katz
& Gruenewald, 1974), in presentation of materi-
als (Flagg, 1976; Flagg & Reynolds, 1977;
James & Hillinger, 1977; Katz, Atkeson, &
Lee, 1974), in instructions (James, Hillinger,
& Murphy, 1977), and in testing procedures
(Anderson & Bower, 1973; Griggs & Keen,
1977; James & Hillinger, 1977) greatly reduce
or eliminate the integration effects found with
the original Bransford-Franks paradigm. Fi-
ally, “integration” will occur for nonsemantic
or arbitrary materials (e.g., letter-digits, non-
sense syllables) if the original procedures are
used (Flagg, 1976; Katz & Gruenewald, 1974;
integration is assumed to be tied to similarities
in the representation of meaning, evidence of
such a process operating on meaningless mate-
rial is troublesome. (p. 216)

Bransford and his colleagues extended this
line of research in several studies also fre-
cently cited in the schema literature. These
studies are dealt with in the next section and fol-
lowing sections.

Bizarre texts
Several studies using bizarre texts have
been influential in popularizing schema theory
in reading. For example, Bransford and John-
son (1972) demonstrated that prior knowledge
was essential to understanding text passages
written so as to be completely obscure without
such knowledge, results that have often been
cited as evidence for the interpretation and in-
tegration processes of schemata. One such ob-
scure passage (“Modern-Day Romeo”) was
presented to subjects who saw a picture of a
complex situation before listening to the pas-
sage and to control groups who did not see
the picture or saw the picture after receiving the
passage. Other obscure passages (“Washing
Clothes,” “Making and Flying Kites”) were pre-
sented with titles rather than pictures, using a
similar experimental design. Results indicated
that the contexts provided by the picture or cued
by the titles produced markedly superior com-
prehension and recall.

The qualities of the bizarre passages used
in this study leave considerable doubt as to their
status as connected discourse. Alba and Hasher
(1983) commented,

Consider now the Bransford and Johnson (1972)
matters that provided the classic demonstra-
tion for the existence of the selection process.
Their passages contain no explicit, concrete
referents, and without a context to suggest ex-
emplars for these referents, none is likely to be
inferred. This should inhibit construction of net-
works of connections among the sentences at
least by preventing extensive use of the given-
new strategy. This would serve to reduce the
possibility that one sentence could cue another
at recall. It is not surprising then that recall of
these materials is so poor; subjects had in effect
been presented with a set of unrelated sentences.
(p. 220)

Other influential schema studies in reading
have used ambiguous texts that were designed
to permit two separate but incompatible in-
terpretations. Chief among these is a study
by Anderson, Reynolds, Schallert, and Goetz
(1977), in which two ambiguous texts were
used: One could be interpreted as relating to ei-
ther a prison break or a wrestling match, and the other as relating to either a game of cards or an evening of music. Results of both multiple-choice comprehension tests and free recall measures indicated that subjects with backgrounds either in music or in weightlifting interpreted the passages in a way consistent with their respective backgrounds, and were often unaware that another interpretation was possible. Two replications of this work (Carey, Harste, & Smith, 1981; Cunard, 1983) showed that not only background experience but also the social location (building) in which the text was read had significant and independent effects on interpretation (but see Henk & Helfeldt, 1987). Other replications showed that adding disambiguating titles or clarifying language to the text also had a significant effect on interpretation that was independent of the subject's background (Cunard, 1983; Sjogren & Timpson, 1979; cf. Schallert, 1976).

Because of the use of texts with contrived ambiguity, the validity and generalizability of the findings from these studies are questionable (Sadoski, 1981). Although most text is ambiguous to some degree (no text is completely explicit), text with a normal degree of clarity and explicit reference is not subject to the either/or interpretations of the texts in these studies. As with the familiar figure/ground illusion that can be seen either as a vase or as two profiles but not as both at once, these texts are designed to accommodate two mutually exclusive interpretations. Other texts that are susceptible to multiple interpretations (e.g., horoscopes) enjoy a qualitatively different form of ambiguity, wherein the reader can simultaneously entertain various interpretations, rather than having to commit to one interpretation to the exclusion of the other for the text to remain coherent. Studies employing ambiguous texts provide impressive demonstrations of the importance of personal background and social locale in the construction of meaning, but their reliance on bizarre texts calls into question their relevance to the reading of naturally occurring texts.

A caveat to this general conclusion should be observed for several schema studies that used cultural differences as an independent variable. Studies by Steffensen, Joag-Dev, and Anderson (1979), Reynolds, Taylor, Steffensen, Shirey, and Anderson (1982), and Harris, Lee, Hensley, and Schoen (1988) showed significant effects of cultural background on recall and importations for text topics that were either culturally familiar or culturally unfamiliar to subjects. Although Steffensen et al. (1979, p. 16) conceded that assigning culturally unfamiliar texts to readers amounts to assigning them bizarre texts, they argued that such effects may reflect the difficulties that ethnic minority children have in learning to read material written for the majority culture. If so, these findings may be among the most educationally relevant in the schema literature. However, we will argue later that the assumption of a schema, cultural or otherwise, is not theoretically necessary for interpreting any of these studies.

**Perspective studies**

A group of schema studies have assigned perspectives to subjects to demonstrate the schema processes of selection and retrieval. Prominent studies in this paradigm are those by Pichert and Anderson (1977; Anderson & Pichert, 1978; Anderson, Pichert, & Shirey, 1983). In these studies, the researchers assigned subjects a perspective—that is, a persona—to assume in reading passages. The central passage in these studies involved two boys who play hooky and visit the home of one of the boys, whose mother is never home on that day of the week. There they note such objects as a tall hedge and landscaping around the house, a garage with 10-speed bikes and an unlocked door, and spacious rooms containing china, silver, a rare coin collection, a new fireplace, a leaky roof, and so on. Subjects were assigned to read and recall this passage from the perspective of either a burglar or a prospective homebuyer. Pichert and Anderson (1977) also included a control condition with no assigned perspective. The resulting ratings of importance of information for a given perspective by one group of subjects generally covaried with recall by another group that was assigned to read the
passage with the same perspective in mind. When subjects were asked to shift perspective for a second recall (without rereading the passage), subjects produced significantly more information that was important from the second perspective but had been unimportant from the first. The findings have generally been consistent for both immediate recall (Anderson & Pichert, 1978; Bloom, 1988; Fass & Schumacher, 1981; Goetz, Schallert, Reynolds, & Radin, 1983; Grabe, 1979; McDaniel, 1984; McDaniel & Kerwin, 1987; Pichert & Anderson, 1977) and delayed recall over various periods (Anderson, Pichert, & Shirey, 1983; Bloom, 1988; Fass & Schumacher, 1981; McDaniel & Kerwin, 1987).

However, a critical examination of the results of these studies suggests that the findings may not be as straightforward as has often been assumed. A persistent anomaly found in these studies is that information important from the burglar perspective is more memorable overall than is the information important from the homebuyer perspective (Anderson & Pichert, 1978; Anderson, Pichert, & Shirey, 1983; Bloom, 1988; Fass & Schumacher, 1981; Goetz et al., 1983; Grabe, 1979; McDaniel, 1984; McDaniel & Kerwin, 1987; Pichert & Anderson, 1977). The explanation usually offered is that college students are unfamiliar with purchasing houses, but are familiar with burglaries from novels and television. However, there is evidence to the contrary, as Grabe (1979) found that his undergraduate subjects could write 10-minute essays on factors to be considered in buying a home. The unfamiliarity explanation is strained, in any case, because one hardly has to be an experienced homebuyer to know that rotting roofs and musty basements are undesirable.

This persistent anomaly demonstrates that prior knowledge differences alone cannot account for the effects found with the contrasting burglar/homebuyer perspectives. In fact, Goetz et al. (1983) found that actual background knowledge (e.g., that of real estate trainees or police officers) was not related to recall or importance ratings; only assigned perspective was. That is, instructions to assume the persona of a burglar or homebuyer were more powerful than real estate trainees’ actual knowledge of real estate values or police officers’ actual knowledge of burglary. We will later suggest a solution to this anomaly that is consistent with dual coding theory.

A different but consistent pattern has emerged with other passages and perspectives. Several studies used a passage involving seagulls that fly around a remote island with exotic flora and features capable of sustaining humans. Subjects were assigned to read the passage from the perspective of either an eccentric florist (or environmentalist) or a shipwrecked sailor (Bloom, 1988; McDaniel, 1984; McDaniel & Kerwin, 1987; Pichert & Anderson, 1977). The passage used in another study involved a young girl’s first day of preschool; readers were assigned the perspective of either a toy manufacturer or a psychologist (Grabe, 1979). Perspective-related differences in recall with these passages have typically been much smaller than for the burglar/homebuyer passage, and differences from a control group have not been significant (Grabe, 1979). This finding suggests that the degree of the recall effect in these studies may be not only perspective-specific but passage-specific as well.

Replications of these studies by McDaniel raise further questions about the effects of schemata in both selection and retrieval (McDaniel, 1984; McDaniel & Kerwin, 1987). In these studies, the processing of certain sentences was made more difficult and elaborate by deleting letters from words. This manipulation resulted in memory effects for those sentences as large as those found for the different perspectives in both short- and long-term recall. Although deleting letters produces somewhat bizarre (mutilated) texts, less bizarre texts without letter deletion produced similar results in a study by Maki and Swett (1987). They argued for an interpretation based on elaboration rather than schema theory. Elaboration or “deep” processing, which occurs due to factors other than abstract knowledge structures, may ultimately explain the results of these studies. In fact, Bloom (1988) empirically tested five different schema-theoretic models (e.g., slot-filling, ex-
tra processing) against his data and concluded that structural, slot-filling models were untenable. The only theoretical model that fit the data was a processing model, in which extra processing accounted for increased recall.

However, the most formidable problem that these studies pose for schema theory involves the selection process in the theory. It is fundamental to schema theory that the schema governs what is selected for encoding by directing attention to certain text information or providing a framework with slots to be filled by certain text information. The schema is also thought to enable probable inferences by "default" where the text is not explicit. If the assigned schema (perspective) in these studies allowed only for the encoding of information that "filled its slots," any remaining information should not have been encoded and should not have been available for later recall. But subjects in these studies were able to recall previously unreported information not salient to their assigned schema for weeks afterward, long after the selection process should have operated to eliminate such information. The fact that subjects were able to recall such information at all indicates that it was encoded and stored in long-term memory in a way not governed by the assigned schema. Drawing default inferences could not plausibly account for these results, either, as there would be no default reason to infer that ladies of houses are never home on Thursdays or that roofs of houses are rotted and leaking, for example. Appeal to the integration process of schema theory would not explain these findings, either, as information not integrated under the governance of an assigned schema should not be available for recall.

The failure of schema theory to account for the selection and encoding of a rich variety of text information, the finding that elaboration in initial processing has effects as strong as those of prior knowledge on retrieval, persistent anomalies in the findings, lack of some effects when control group comparisons are made, and serious questions about generalizability should cause reading researchers and educators to be cautious about the conclusions offered in these perspective studies.

In summary, much of the support for schema theory may have stemmed from procedural peculiarities of key studies, as noted in the critical review by Alba and Hasher (1983). Among these peculiarities are reliance on contrived experimental texts and methods whose effects (a) are difficult to replicate with other texts and methodological variations, (b) exhibit persistent anomalies, (c) violate the very assumptions of schema theory, and/or (d) invite alternative interpretation.

**Dual coding theory**

It is commonly considered unavailing to criticize a popular theory without offering an alternative. In the remainder of this paper we will present and discuss an alternative to schema theory: dual coding theory. Although the origins of dual coding theory are closely contemporaneous with those of schema theory, dual coding theory, like imagery itself, has generally been neglected by reading researchers. After providing a brief overview of the theory, we will show that dual coding theory, with its two components—a verbal system and an imagery system—can account for the data cited in support of schema theory as well as other findings. Finally, we will show that dual coding theory compares favorably with other current theories such as van Dijk and Kintsch's (1983) discourse processing model and propositional or semantic network models.

**Overview of the theory**

Like schema theory, dual coding is not specifically a reading theory, but a theory of cognition. Dual coding theory attempts to explain linguistic cognition and nonlinguistic cognition and the relations between the two. The development of the theory has included the systematic investigation of these relations at the word, phrase, sentence, and text levels, and predictions from it have been tested against the predictions of competing theories, such as propositional network and tacit knowledge theories, with consistently favorable results. Dual coding
The theory and its empirical record have been extensively documented by Paivio (1971, 1986, in press).

The theory holds that cognition consists of the activity of two separate mental subsystems, one specialized for the representation and processing of information concerning nonverbal objects and events, and the other specialized for dealing with language. The nonverbal subsystem is often referred to as the imagery system because its functions include the analysis of scenes and the generation of mental images (visual as well as in other modalities such as auditory, haptic, and affective). The language-specialized subsystem is referred to as the verbal system. These systems are separate but interconnected, so that they can function independently, in parallel, or in an integrated manner.

The two systems have different organizational and processing characteristics. Information in the verbal system is organized in a way that favors sequential, syntactic processing, whereas nonverbal information (especially in the visual modality) is organized more in the form of holistic nested sets with information available for processing in a synchronous or parallel manner. Interconnections between the systems allow for great variety in cognitive activity.

Figure 1 provides a model of the general structures and processes assumed by dual coding theory. Sensory systems detect verbal and nonverbal stimuli and continually activate mental representations (via the representational connections in Figure 1). These representations are labeled logogens in the verbal system (cf. Morton, 1979), and imagens in the nonverbal system (cf. iconogen, Attnavee, 1974). These are theoretical constructs corresponding to the elementary units within each system and are assumed to have some neurological basis. The modality and size of the units can vary, so that a logogen could correspond to a phoneme, grapheme, morpheme, word, phrase, or a larger familiar unit, and an imagen could represent a natural object (or sound, etc.), a part of that object, or a natural grouping of objects.

These representations form hierarchical organizations within each system. The boxes and arrows within the verbal system indicate the sequential, syntactic organization of the structures, which can be logically hierarchical. For example, certain arrangements of morphemes make words, certain arrangements of words make sentences, certain arrangements of words and sentences make connected texts, and so on. The set diagram arrangement of the nonverbal system indicates the holistic, nested set organization of those structures. For example, eyes, noses, or mouths can be perceived separately, but are normally perceived as parts of a face, faces as part of heads, heads as part of bodies, and so on. Even the eye is a nested set, having a pupil, iris, eyelashes, and so on.

Organization can work within a system or between the systems. Intra-system organization is called associative (associative structures in Figure 1). Words or phrases are associated through experience or learning with other words or phrases (Deese, 1962, 1965). For example, the phrase once upon a time may suggest (predict) other language units such as long ago, princess, prince, lived happily ever after, or other verbal associations from our experience. These associations are probabilistic. For example, it is unlikely that once upon a time would predict fuel injection as an associate, but certain experiences or contexts could make that association more probable. Likewise, mental images could evoke other associated images. For example, a mental image of a fork might also evoke an image of an entire place setting and even a dining experience. These associations are also probabilistic, dependent on experience and situational constraints.

Inter-system relations are referential (referential connections in Figure 1). Language can evoke imagery, and imagery can evoke language (again, probabilistically). These connections are not one-to-one but one-to-many. Hence, language could referentially evoke numerous images or no imagery at all, and mental images could referentially evoke much language or no language at all. These referential interconnections allow for the great flexibility noted in human cognition.
A useful analogy for understanding the role of language in dual coding theory is Saussure's (1915/1974) analysis of language as a system of signs, in which he compares language to currency. The value of money can be expressed in two different ways. On the one hand, money has a formal, within-system, syntactic value, such that a five-dollar bill can be exchanged for any combination of other bills or coins that totaled five dollars. On the other hand, money has value in terms of the goods and services for which it can be exchanged. Analogously, dual coding theory holds that linguistic representations can be interpreted in relation to other linguistic representations (e.g., synonyms, paraphrases, syntactic alternatives) or in relation to nonlinguistic representations of the objects, events, or feelings for which they stand (e.g., images, affects). To continue the analogy, we can trade goods and services for other goods and services, or for money. Similarly, dual coding also posits associative processing within the nonverbal system (images evoking other images) and referential processing from the non-
verbal system to the verbal system (images evoking language). A fuller analysis of language and its relation to imagery is detailed in Paivio and Begg (1981).

Processing in dual coding theory includes external and internal variables. External contexts, situational constraints, instructions, and so on, interact with a person's two existing symbolic systems, as determined by prior experience and individual differences. Processing can be conscious or unconscious, and often involves the transformation and recoding of representations. An important point here is that the theory does not include any separate abstracted structure such as a schema. Processing consists of the probabilistic activation of particular verbal and/or nonverbal mental representations by external stimuli or by previously activated representations. Because dual coding does not assume the necessary existence of a schema, or processing under the guidance of a schema, it can better account for the great detail found in memory for events, as well as the flexible construction and reconstruction of events in memory. The following section will provide examples of how dual coding theory can account for some of the problematic findings from the schema studies.

Reinterpretation of schema studies

The results of schema research can be alternatively interpreted in terms of the verbal and imagery systems of dual coding theory. In some cases, such an alternative explanation has been noted by the researchers themselves. One particularly prominent example comes from the work of Bransford, Barclay, and Franks (1972), who extended Bransford and Franks's (1971) investigation of interpretation and integration. Specifically, they sought to determine whether subjects interpreted sentences semantically—that is, whether they comprehended the deep structures of the sentences, or instead constructed "semantic descriptions of situations" (p. 194) containing more information than the stimulus sentences contained. The methodology involved systematically varying two sections of sentences so as to admit or not admit certain inferences, as in the sentence *Three turtles rested (on/aside) a floating log and a fish swam beneath (it/them)*. Subjects' recognition of both the original sentences and the inferences admitted by the original sentences suggested that more was available in memory than just the information specified by the sentences. The authors concluded that subjects had constructed holistic situational representations that went beyond the deep-structure interpretation of sentences. They suggested that these representations might well be visual images of the situations, and noted that many of their subjects spontaneously reported constructing such images, a point that later schema theorists seem to have disregarded.

On the other hand, the authors asserted that imaginal and linguistic representations alone would not account for all their findings, and that a more general semantic representation was required. However, the experiment provided direct empirical evidence only for linguistic representations and images, and not for these "semantic descriptions." Dual coding theory can account for the observed results in terms of the specific functions of the verbal and imagery systems without recourse to a general, separate semantic representation.

It should be noted that the Bransford and Franks (1971) materials involved very concrete sentences, but Franks and Bransford (1972) found similar results with very abstract sentences and concluded that sentence integration did not depend on mental imagery. However, Wippich (1988), using the same concrete and abstract sentences as were used in these studies, found reason to doubt the holistic integration of abstract sentences. In two related experiments, Wippich found integration effects that strongly favored concrete over abstract sentences in results from recognition, reconstruction, and inference tasks that tapped various aspects of text processing. His conclusions strongly support the dual coding view of qualitative differences in the integration of concrete and abstract sentences and texts. Paivio (in press) provides further explanation of and evidence for qualitative differences in the integration of concrete and abstract texts that are consistent with dual coding theory.
Dual coding can also address the role of imagery in the bizarre text studies. It is important to note that the use of a picture was necessary in effecting comprehension of the “Modern-Day Romeo” passage (Bransford & Johnson, 1972). Bransford and Johnson noted that even the use of a disambiguating title, “Possible Breakdowns in Communication During a Serenade” (p. 274), was not sufficient to produce comprehension or recall equal to that resulting from use of the picture. Although the novelty of this passage may have made it virtually impossible to comprehend it without a picture, titles that specified concrete referents (“Washing Clothes,” “Flying Kites”) were sufficient to improve comprehension of other passages.

Stein, Brock, Ballard, and Vye (1987) have extended these findings. Subjects read confusing texts and read verbal elaborations or viewed pictures that either did or did not clarify the confusion. They found that either clarifying verbal elaborations or clarifying pictures improved retention significantly. They drew the following conclusion:

The picture facilitation effects reported in the present study are consistent with the idea that certain aspects of the visual image may be represented differently in memory than verbal information (e.g., Nelson & Castano, 1984; Paivio, 1971). The present findings suggest that this alternate representation can be used in certain situations to improve the retention of verbal information. (p. 289)

Stein et al. also suggested that visual images would not necessarily have to be presented as pictures, but could be imagined by readers from the clarifying verbal elaborations.

Hence, some of the schema studies have already attracted interpretation or reinterpretation in dual coding terms. Results from the ambiguous text studies can also be explained by dual coding theory. Because of the ambiguity of the texts, readers relied heavily on personal background and situational cues to interpret the text and form images. For example, when the prison break/wrestling passage was read by weightlifters in a physical education setting, the probability was greater that words such as mat, lock, held, and escape would activate verbal representations associated with wrestling, and would evoke integrated, dynamic images of wrestlers grappling. These images guided the interpretation of the whole passage. Other images from watching or participating in wrestling matches (and the appropriate referent language) might also be associatively encoded in the episode, whether or not the images were evoked by language in the text. Information from these images would then appear verbally as “theme-revealing disambiguations and intrusions” (Anderson et al., 1977, p. 375) in recall. This explanation might be seen as a paraphrase of the schema interpretation, but the difference is significant because the associative and referential mechanisms of dual coding are simpler and more explicit than those of schema theory. The importance of this distinction will be highlighted by consideration of the studies reviewed next.

The perspective studies in schema research can also be interpreted in dual coding terms. In the case of the burglar/homebuyer passage, the dual coding interpretation would be that the verbal instructions and the passage together activated different patterns of verbal and imaginal encoding. Prior experiences with descriptions or movies of burglaries, for example, would affect encoding so that the verbal cue burglar is more likely to prime (predict) stereo equipment or silverware than leaky roof as verbal associates, whereas the converse is true for the verbal cue homebuyer. The different patterns of verbal activation referentially induce different patterns of imagery. Imagery, being more holistic in nature, allows for the additional encoding of much text information not salient to the assigned perspective. For example, the passage describes three 10-speed bikes and an unlocked door found in a garage. If this information were integrated into an image of the garage and its contents, the information that the house had a garage (important for the homebuyer perspective) would become just as available for recall as the information that 10-speed bikes would be available for theft and that an unlocked door would facilitate entry (important for the burglar

...
perspective). This explanation could quite plausibly account for the significant additional amount of information recalled when subjects were asked to take the opposite perspective. Because much of this passage is a mental tour of the premises, such an imagery effect could be very significant overall. As noted previously, the additional recall from the opposite perspective is difficult to reconcile with the selection and/or integration processes posited by schema theories.

The effect of imagery in perspective studies has been noted by other researchers. Owens, Dafoe, and Bower (1977) induced readers of a water-skiing passage to identify with either the water skier or the driver of the boat. The procedure resulted in different patterns of recognition errors and other findings consistent with the two perspectives. Moreover, when asked to describe the mental images they experienced while reading the story, their responses revealed spatial perspectives that corresponded to the different viewpoints of the characters. For example, subjects who identified with the skier imagined the scene as though it were through the skier's eyes and recalled the skier's actions as if they themselves had been performing them, but imagined the boat driver's actions from the point of view of an outside observer. The dual coding interpretation is that these differences were initiated by verbal instructions and story cues, which induced patterns of prediction and association in the verbal system, which in turn induced referential imagery.

A study by Black, Turner, and Bower (1979) is particularly important in this regard because it reveals the effects of even subtle linguistic differences on imagined perspectives and on comprehension. The study contrasted verbs such as come and go in compound sentences. The first clause of each compound sentence introduced a character and his or her location, and the second clause described an event from either the same or a different vantage point. For example, Terry finished working in the yard was followed by either and went into the house or and came into the house. The former has a consistent perspective from an observer outside the house, whereas the latter requires a change in perspective. Findings indicated that it took significantly longer to comprehend the clause with the changed perspective than the one with a consistent perspective. The results of a second experiment indicated that the sentences that changed perspective were also rated relatively harder to understand. These results are readily interpreted in terms of the visual imagery suggested by dual coding theory.

### Dual coding and studies of imagery and affect in reading

In this section, we will briefly review key studies of imagery and affect in reading with findings that are more easily explained by dual coding theory than by schema theories. A variety of recent studies have shown that imagery occurs consistently, spontaneously, and naturally during reading, both for children and adults and when reading both narrative and expository texts (Long, Winograd, & Bridge, 1989; Sadoski, 1983, 1985; Sadoski, Goetz, Olivarez, Lee, & Roberts, 1990). A crucial finding of these studies is the distinction found between verbal and imaginal information in subjects' protocols. Information in self-reports of imagery overlaps only partially with information in verbal recalls. Moreover, frequency counts of variables derived from verbal recalls and variables derived from imagery reports correlate at only low to moderate levels, and scores on variables derived from imagery reports do not correlate significantly with general verbal measures such as scores on standardized reading comprehension, vocabulary, or intelligence tests or cloze tests.

For example, Sadoski et al. (1990) found low to moderate correlations between five variables derived from subjects' verbal recalls of a story and eight variables derived from the same subjects' imagery reports. A factor analysis revealed that the variables from verbal recalls and imagery reports loaded together on a series of factors, with imagery report variables dominating some of the factors and verbal recall variables dominating the other factors. An earlier factor analysis with other verbal and imagery variables revealed this same general pattern (Sadoski, 1983), which was subsequently repli-
cated (Sadoski, 1985). These correlational results are consistent with the dual coding assumption that the verbal and nonverbal systems are functionally independent but have the capacity to cooperate through interconnections.

These findings are more difficult for schema theories to explain. If the mental representation of a text is stored in a common, abstract form under the overriding control of a schema, story information in readers' protocols should be relatively consistent, regardless of whether they are asked to recall the passage or report their images. That is, if a schema governs the selection of story information, stores it in an abstract, integrated form, and influences its retrieval, then readers' protocols should be quite similar whether the task was to report verbal recall or to report imagery, and correlations between respective verbal and imagery variables derived from this common source should be high. However, if information was encoded in two separate but interconnected forms, verbal and imaginal, the respective protocols and correlations should reflect a general but not complete distinction. The results cited are more consistent with the dual code explanation.

The argument here is similar to the argument raised regarding the perspective studies, which found that readers regularly supply additional information after a shift in perspective. Schema theory suggests that a schema governs the selection and storage of the information that was important to that schema, yet it has been found that readers can regularly recall other information not important to the schema. Dual coding readily accounts for the accessibility of this other information, whereas schema theory does not. Here, dual coding theory better accounts for the distinctions found between verbal recall variables and imagery report variables in the correlations and factor analyses. Dual coding theory has elsewhere been experimentally tested against schema theory using other paradigms (e.g., word lists), and the results were particularly supportive of the verbal-associative aspects of dual coding theory (Khan & Paivio, 1988).

Another area of text processing receiving increased attention is affective response to reading. A variety of researchers have shown interest, liking, and emotions to be significant variables in readers' responses when reading, as well as in their learning from and memory for what was read (Brewer & Lichtenstein, 1981; Hidi & Baird, 1986, 1988; Iran-Nejad, 1987a; Sadoski & Goetz, 1985; Sadoski, Goetz, & Kangiser, 1988; Sadoski & Quast, 1990; Wilensky, 1983). A common finding of these studies is that emotional responses operate differently than would be predicted on the basis of the long-term memory structures posited by schema theory. The main processing assumption of schema theory has been that readers' preexisting mental structures govern comprehension at the time of reading through instantiation; that is, through selection, abstraction, and integration. It is not clear how such processing assumptions can explain the comprehension of surprising or novel information not provided for by the schema (Brewer & Lichtenstein, 1981; Iran-Nejad, 1987a; Wilensky, 1983). For example, Iran-Nejad (1987a) experimentally studied cognitive and affective causes of interest and liking in stories with surprise endings, and concluded that schema theories of memory are not equipped to deal with affect. He argued for a dynamic, functional theory of comprehension and recall that includes affect.

The retrieval processes of schema theory also cannot easily explain the powerful effects of affective and imaginal variables on recall. The retrieval processes of schema theory suggest that what is recalled will be information that is important to the governing schema. However, several studies have shown that interest, emotional response, and imagery are better predictors of text recall than is importance (Garner, Gillingham, & White, 1989; Hidi & Baird, 1988; Sadoski & Quast, 1990). This finding holds even for college students reading articles from popular magazines on topics about which the general public is assumed to have some prior knowledge (Sadoski & Quast, 1990).

Finally, we speculate that the influence of affect and imagery might explain the persistent anomaly found in the perspective studies noted earlier. That is, in the burglar/homebuyer pas-
sage that is central to these studies, information salient to the burglar perspective was better recalled than information salient to the homebuyer perspective, despite evidence that prior knowledge was available for both perspectives. This effect may be due to more affective arousal when the burglar persona is assumed than when the homebuyer persona is assumed. There may be a certain vicarious excitement to casing a joint for a burglary, whereas inspecting real estate seems much more mundane. The dual coding interpretation suggested for the results found with this passage might be extended to account for this effect, because imagery and affect variables are theoretically related and are regularly found to be significantly correlated in reading text.

In summary, a body of research exists on imagery and affect in reading which is consistent with the general assumptions of dual coding theory but not with the general assumptions of schema theory. However, much remains to be learned about the roles of imagery and affect in text processing.

Comparison with other theories

Although schema theory and reading research have generally neglected the role of imagery, there are a number of recent theories that resemble dual coding theory in placing greater emphasis on imagery. For example, Fillmore (1977) modified his case grammar theory (1968) by putting more emphasis on the perceptual (or imagined) scenes to which linguistic terms are related. Meanings, he maintains, are relative to scenes, in that the viewer's perspective can differ depending on the emphasis or saliency of such grammatical cases as agent, instrument, and object. These differences in perspective are implied by the cases and grammatical structures of language, including active/passive differences in construction. Lakoff (1977) and Chafe (1975) have similarly emphasized the role of concrete situations and related actions in semantic and grammatical distinctions. They maintain that linguistic elements and structures not only relate to perceptual-motor experiences, but derive from them and depend on them for meaning (see Skemp, 1987, for the same conclusion regarding mathematics). Similar ideas are implicit in current uses of mental models in explaining text comprehension (e.g., Johnson-Laird, 1983; Morrow, 1985).

One of the most influential models of text comprehension has been the Kintsch and van Dijk model (Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983). This model has been worked out in considerable detail and has been used by many investigators of text processing. It has continually been extended and elaborated in ways that make it increasingly compatible with dual coding theory.

The original model (Kintsch & van Dijk, 1978) assumed that discourse is interpreted as a set of propositions ordered by various semantic relations between the propositions. The resulting semantic structure is divided into microstructure and macrostructure levels. These two structural levels are related by a set of semantic mapping rules called macrorules, which derive from and are applied by a general schema. However, some research indicated that this model was too simple, and suggested that it should incorporate two interacting memory systems, one for episodically “chunked” macrostructure information and another for processing microstructure information (Spilich, Vesonder, Chiesi, & Voss, 1979).

The updated model proposed by van Dijk and Kintsch (1983) elaborates their original view in several ways. The new model distinguishes three levels of text representation in memory, including a surface representation, a propositional text base (much like the one in the original version), and a situation model. The situation model is not assumed to be part of the text representation proper, but instead is viewed as a model that the reader constructs about the situation denoted by the text. Van Dijk and Kintsch argue that situation models are required to account for such linguistic and psychological phenomena as reference, coreference, coherence, situational parameters, and perspective. The addition of a situation model to the general theory renders it more similar to dual coding theory, which includes holistic, situational representations that can be experienced as mental.
imagery. However, van Dijk's and Kintsch's (1983) proposed representational structure for situation models is a schematic propositional format (pp. 344-346). This is not consistent with the dual coding view that schematic propositional formats are theoretically unnecessary (Paivio, 1986, pp. 225-227).

However, recent work by Perrig and Kintsch (1985) has brought the model still closer to the dual coding view. Perrig and Kintsch compared memory for two texts that presented the same information about the geography of a fictitious town (e.g., landforms, streets, buildings) but differed in organization (i.e., a survey of the town's geography vs. directions for driving a route through the town). In two experiments, the route version generated better comprehension and recall, whereas the survey text produced more correct spatial inferences. The recall of the route text was often in linear order, whereas the survey text was often reorganized in recall. The researchers also found that many subjects appeared to form images of the route text as well as the survey text. Perrig and Kintsch concluded that variables in the text and individual differences between readers combined to form two qualitatively different representations for the texts: a mental list of procedural instructions in a sequential, verbal representation, and an integrated situation model or mental map in the form of a mental image. Findings similar to the Perrig and Kintsch results using other procedures and narrative texts have been reported by Morrow, Greenspan, and Bower (1987) and by Glenberg, Meyer, and Lindenn (1987). Both argue for mental models of the text that take a visuo-spatial form. Schmalhofer and Glavanov (1986) have reported similar findings and conclusions using expository text from a computer programmer's manual.

The above interpretations are all very compatible with general and specific assumptions of dual coding theory. Specifically, the van Dijk and Kintsch (1983) model as elaborated by Perrig and Kintsch (1985) can be compared with dual coding in the following way. The elaborated model posits three codes for representation: (a) the surface, or verbatim text representation, where verbatim is meant to include close paraphrases of the text's original language such as synonym substitutions, omissions, and the like (van Dijk & Kintsch, 1983, pp. 362-363); (b) the propositional model of the text; and (c) the situation model of the text in imaginal form. Dual coding posits two codes: the verbal code, which corresponds roughly to van Dijk and Kintsch's idea of verbatim surface representation and is specialized for handling verbal sequences, and the nonverbal code, which corresponds to the visuo-spatial situation model. There is no abstracted, propositional model of the text in dual coding theory; the operation of the verbal code and interconnections with the nonverbal code are sufficient to account for the representation of the text and a propositional model would not contribute anything more to the explanation. However, the verbal code in dual coding theory presumably handles such operations as linguistic cohesion (Halliday & Hasan, 1976) and allows for a wider network of semantic associations than the term verbatim would connote.

In this sense, the verbal code can also be seen as somewhat similar to semantic network and spreading-activation models (e.g., Collins & Loftus, 1975; J.R. Anderson, 1983). Spreading activation in a network is assumed in dual coding, in that one representation activates another via associative pathways within the verbal code and via referential pathways to the nonverbal code. The closest parallel to dual coding's nonverbal system is the idea of concept nodes, which Collins and Loftus distinguish from linguistic representations. The important difference is that concept nodes are seen as abstract and amodal, whereas dual coding theory assumes that the nodes are modality-specific and holistic. If semantic network theories themselves, however, do not allow for referential connections to a nonverbal code. The closest parallel to dual coding's nonverbal system is the idea of concept nodes, which Collins and Loftus distinguish from linguistic representations. The important difference is that concept nodes are seen as abstract and amodal, whereas dual coding theory assumes that the nodes are modality-specific and holistic. If semantic network theories were expanded to include nonverbal, imaginal representations, they would also conform to dual coding theory in many important ways. Johnson-Laird, Hermann, and Chaffin (1984) have criticized the entire family of semantic network theories on very similar grounds.
In summary, dual coding theory can account for the results of schema studies without reliance on reified, abstract knowledge structures, and it can explain recall results that are difficult to explain using the mechanisms of schema theory. Furthermore, numerous researchers have converged on theories of mental modeling that incorporate the assumptions of dual coding, and other theories could be readily modified to include dual coding assumptions.

**Conclusion**

As we noted at the outset, contemporary reading research has been greatly influenced by schema theory. By focusing attention on the constructive nature of comprehension and on the role of the reader’s prior knowledge, schema theory has inspired a wealth of empirical research and has enriched our understanding of the nature of reading. However, because of the dominance of schema theory, the reading field has perhaps lost some of the benefits of the theoretical plurality enjoyed by the broader field of cognitive psychology. An unfortunate pattern in the development of our knowledge about reading and the teaching of reading has been a tendency toward an overemphasis on one theory or approach.

In this article we have provided a theoretical alternative that accounts for the prior knowledge effects that schema theories can account for as well as other effects, without many of the problems that have perennially beset schema theories. We have argued that schema theory is flawed by serious definitional, epistemological, and empirical problems. We have shown that much of the empirical foundation of schema theory lies in procedural singularities which have produced findings that are at times inconsistent with the theory’s own assumptions, but which can be interpreted consistently by dual coding theory. We have also shown that some theories of text processing have now evolved to include a fundamental place for mental situation models, rendering these theories quite consistent with dual coding theory but not with proposition-based schema theories.

We concede that valid criticisms can be raised against any existing theory of cognition in reading. But such criticism is essential to progress. Theories and constructs are useful only as long as they evolve in their heuristic, explanatory, and predictive functions, and the evolution of theories is best carried out in an environment of constructive scrutiny, where no theory is accepted uncritically. We believe that consideration of dual coding theory will offer reading researchers new and viable theoretical alternatives for interpretation of their studies, and will serve to promote continued progress in the development of knowledge about a wider spectrum of reading phenomena.

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Footnote
The authors wish to thank Mary Walsh, Albert Katz, Mustaq Khan, and Jon Denton for their helpful comments on earlier drafts of this article.

Received April 27, 1990
Revision received December 27, 1990
Accepted July 2, 1991